CLAIMS

What is claimed is:

1. A field emission device, comprising:

a substrate having a deformation temperature that is less than about six hundred and fifty degrees Celsius;

a nano-supported catalyst formed on said substrate, said nano-supported catalyst having active catalytic particles that are less than about five hundred nanometers; and

a nanotube that is catalytically formed in situ on said nano-supported catalyst, said nanotube having a diameter that is less than about twenty nanometers.

2. The field emission device of Claim 1, wherein said nanotube with said diameter that is less than about twenty nanometers is configured to provide a switching voltage that is less than about eighty volts.

3. The field emission device of Claim 1, wherein a current density drawn from said field emission device is greater than about one-half milliamp per squared centimeter.

4. The field emission device of Claim 1, wherein said nanotube that is catalytically formed in situ on said nano-supported catalyst is catalytically formed in situ on said nano-supported catalyst with hot filament chemical vapor deposition (HFCVD).

5. The field emission device of Claim 2, wherein said switching voltage is less than about fifty volts.

6. The field emission device of Claim 1, wherein said active catalytic particles are less than about fifty nanometers.

7. The field emission device of Claim 1, wherein said diameter of said nanotube is less than about five nanometers.

8. The field emission device of Claim 1, wherein said nanotube has an aspect ratio of greater than approximately one hundred and forty and less than approximately four thousand and five hundred.

9. The field emission device of Claim 1, wherein said nanotube is single-wall nanotube.

10. The field emission device of Claim 1, wherein said nanotube is multi-wall nanotube.

11. The field emission device of Claim 3, wherein said current density drawn from said field emission device is greater than about one and one-half milliamp per squared centimeter.

12. The field emission device of Claim 1, wherein said substrate comprises at least one material selected from the group consisting of borosilicate glass, sodalime glass, carbon, silicon, ceramics, metals, and composite materials.

13. The field emission device of Claim 1, wherein said field emission device is configured to provide a gate spacing of less than about twenty-five microns.

14. The field emission device of Claim 1, further comprising an anode.

15. The field emission device of Claim 14, wherein a second distance between said anode and said substrate is greater than about two hundred and fifty microns and less than about five thousand microns.

16. The field emission device of Claim 1, wherein a thickness of said nano-supported catalyst is less than one micron.

17. The field emission device of Claim 1, wherein said nano-supported catalyst is comprised of said active catalytic particles that are selected from the group consisting of iron, nickel, cobalt and a metal oxide selected from the group consisting of alumina, silica and magnesium oxide.

18. The field emission device of Claim 1, wherein said nano-supported catalyst is comprised of:

a porous sub-layer having said active catalytic particles supported by a metal oxide structure; and

a non-porous sub-layer having said active catalytic particles and a structural metallic element.

19. The field emission device of Claim 18, wherein said porous sub-layer has a surface area to volume ratio of greater than about fifty meter square per gram (50 m^2/g).

20. A method of forming a field emission device comprising:

providing a substrate having a deformation temperature that is less than about six hundred and fifty degrees Celsius;

forming a nano-supported catalyst on said substrate, said nano-supported catalyst having active catalytic particles that are less than about five hundred nanometers; and

conducting a chemical reaction process to grow a nanotube on said nano-supported catalyst, said nanotube having a diameter that is less than about twenty nanometers.

21. The method of forming the field emission device of Claim 20, wherein said field emission device is configured to provide a switching voltage that is less than about eighty volts with a current density drawn from said field emission device that is greater than about one-half milliamp per squared centimeter.

22. The method of forming the field emission device of Claim 20, wherein said chemical reaction process is comprised of a hot filament chemical vapor deposition (HFCVD).

23. The method of forming the field emission device of Claim 20, further comprising of depositing a bleed layer of conductive material.

24. The method of forming the field emission device of Claim 17, wherein said forming said nano-supported catalyst on said substrate is comprised of:

immersing said substrate into a solvent containing a first metal salt and a second metal salt; and

applying a bias voltage to said electrode such that said nano-supported catalyst is at least partly formed with said first metal salt and said second metal salt on said substrate.

25. The method of forming the field emission device of Claim 24, wherein said first metal salt is selected from the group consisting of aluminum nitrate, magnesium nitrate, calcium nitrate or combination thereof.

26. The method of forming the field emission device of Claim 24, wherein said active catalytic particles are derived from said second metal salt and are selected from the group consisting of iron, nickel, cobalt, ruthenium, rhodium, palladium, rhenium, osmium, iridium and platinum.

27. The method of forming the field emission device of Claim 20, wherein said forming said nano-supported catalyst on said substrate is comprised of:

immersing said substrate into a first solvent containing a first metal salt;

applying a first bias voltage such that said nano-supported catalyst is at least partly formed with said first metal salt on said substrate;

removing said substrate from said first solvent containing said first metal salt;

immersing said substrate into a second solvent containing a second metal salt; and

applying a second bias voltage in said second solvent such that said nano-supported catalyst is partly formed with said second metal salt.

28. The method of forming the field emission device of Claim 27, wherein said first metal salt is selected from the group consisting of aluminum nitrate, magnesium nitrate and calcium nitrate.

29. The method of forming the field emission device of Claim 27, wherein said active catalytic particles are derived from said second metal salt, which is selected from the group consisting of iron, nickel, cobalt, ruthenium, rhodium, palladium, rhenium, osmium, iridium and platinum.

30. The method of forming the field emission device of Claim 20, wherein said forming said nano-supported catalyst is comprised of:

depositing an active catalytic metallic element on said substrate;

depositing a structural metallic element with said active catalytic metallic element to form a mixed metal alloy layer on substrate; and

etching said mixed metal alloy layer with an etchant to oxidize said active catalytic metallic element and said structural metallic element and to remove at least a portion of said structural metallic element from a first sub-layer of said mixed metal alloy layer, wherein said first sub-layer of said mixed metal layer is porous and comprised of said active catalytic particles of said active catalytic metallic element and supported by a metal oxide structure derived from the structural metallic element, and said mixed metal alloy layer other than said first sub-layer and said first sub-layer form the nano-supported catalyst on said substrate.

31. The method of forming the field emission device of Claim 30, wherein said active catalytic metallic element and said structural metallic element have different electrochemical selectivity so as to allow said etchant to remove at least a portion of said structural metallic element from a first sub-layer of said mixed metal alloy layer.

32. The method of forming the field emission device of Claim 30, wherein said depositing said active catalytic metallic element on said substrate and said depositing said structural metallic element with said active catalytic metallic element to form said mixed metal alloy layer on said substrate is accomplished with a coevaporation deposition.

33. The method of forming the field emission device of Claim 30, wherein said active catalytic metallic element is selected from the group consisting of titanium, vanadium, chromium, manganese, copper, zirconium, niobium, molybdenum, silver, hafnium, tantalum, tungsten, rhenium, gold, ruthenium, rhodium, palladium, osmium, iridium, platinum, iron, cobalt and nickel.

34. The method of forming the field emission device Claim 30, wherein said structural metallic element is selected from the group consisting of aluminum, silicon and magnesium.

35. The method of forming the field emission device Claim 30, further comprising adding a catalytic promoter as a ternary element.

36. The method of forming the field emission device of Claim 31, wherein said ternary element is selected from the group of consisting of calcium, tantalum, hafnium and zirconium.

37. The method of forming the field emission device Claim 30, wherein said etchant is selected from a group consisting of ammonium hydroxide solution, an alkaline solution, a nitric acid solution, a hydrochloric acid solution, and an acidic solution.

38. The method of Claim 20, further comprising forming a gate having an aperture.

39. The method of Claim 38, wherein forming said gate having said aperture is comprised of:

forming a sacrificial layer of material surrounding said nano-supported catalyst, said sacrificial layer having a depth and width that defines a gate separation from said nano-supported catalyst;

forming a gate seed layer on said sacrificial layer;

forming a first mask on said gate seed layer, said first mask defining said gate aperture and gate edges;

depositing a gate layer on said gate seed layer using said first mask, said gate layer and said gate seed layer combining to form said gate;

removing said first mask;

etching an opening through said gate seed layer using said gate layer as a second mask; and

removing said sacrificial layer surrounding said layer of nano-supported catalyst.